

## CLAIMS

1. An aqueous acidic iron phosphorus bath comprising  
(A) at least one compound from which iron can be electrolytically  
deposited,

5 (B) hypophosphite ion, and  
(C) a sulfur-containing compound selected from sulfoalkylated  
polyethylene imines, sulfonated safranin dye, and mercapto aliphatic sulfonic acids or alkali  
metal salts thereof.

2. The bath of claim 1 wherein the iron compound is selected from ferrous  
10 chloride, ferrous sulfate, ferrous fluoroborate, ferrous methane sulfonate, ferrous sulfamate  
and mixtures thereof.

3. The bath of claim 1 wherein the source of hypophosphite ion is  
hypophosphorus acid, an alkali metal hypophosphite salt, or a mixture thereof.

4. The bath of claim 1 wherein the sulfur-containing compound is a mercapto  
15 aliphatic sulfonic acid, an alkali metal salt thereof, or a mixture thereof.

5. The bath of claim 1 wherein the sulfur containing compound is represented  
by the formula



wherein X is H or an alkali metal, R<sup>1</sup> is an alkylene group containing from 1 to about 5  
20 carbon atoms Y is H, S-R<sup>1</sup>-SO<sub>3</sub>X, C(S)NR<sub>2</sub>"', C(S)OR"', C(NH<sub>2</sub>)NR<sub>2</sub>"', or a heterocyclic  
group, and each R"' is independently H, or an alkyl group containing from 1 to about 5  
carbon atoms.

6. The electroplating bath of claim 1 also comprising aluminum ions.

7. The bath of claim 1 wherein the pH is from about 0.5 to about 5.

25 8. The bath of claim 1 wherein the bath is free of complexing agents.

9. The bath of claim 1 wherein the source of ferrous ion comprises ferrous  
sulfate and ferrous chloride.

10. An aqueous acidic iron phosphorus electroplating bath comprising

(A) from about 20 to about 120 grams per liter of ferrous ion,

(B) from about 0.2 to about 8 grams per liter of phosphorus, said phosphorus being supplied as hypophosphite ion, and

(C) from about 0.001 to about 0.5 grams per liter of sulfur present as a sulfur-containing compound selected from sulfoalkylated polyethylene imines, sulfonated safranin dye, and mercapto aliphatic sulfonic acids or alkali metal salts thereof.

11. The electroplating bath of claim 10 wherein the ferrous ion is present as at least one salt selected from ferrous chloride, ferrous sulfate, ferrous fluoroborate, ferrous methane sulfonate, ferrous sulfamate, and mixtures thereof.

12. The electroplating bath of claim 10 wherein the phosphorus is present as hypophosphorus acid, an alkali metal hypophosphite salt, or mixtures thereof.

13. The electroplating bath of claim 10 wherein the sulfur-containing compound is a mercapto aliphatic sulfonic acid compound or salt thereof.

14. The plating bath of claim 10 wherein the sulfur containing compound is represented by the formula



wherein X is H or an alkali metal,  $R^1$  is an alkylene group containing from 1 to about 5 carbon atoms Y is H,  $S-R^1-SO_3X$ ,  $C(S)NR_2''$ ,  $C(S)OR''$ ,  $C(NH_2)NR_2''$ , or a heterocyclic group, and each  $R''$  is independently H, or an alkyl group containing from 1 to about 5 carbon atoms.

15. The electroplating bath of claim 10 wherein the bath also comprises from about 0.1 to about 10 grams per liter of aluminum ions.

16. The plating bath of claim 10 wherein the bath has a pH of from about 0.8 to about 2.5.

17. The plating bath of claim 10 wherein the bath is free of complexing agents.

18. A process for electrodepositing an iron-phosphorus alloy on a conductive substrate which comprises

(A) providing an acidic aqueous electroplating bath of claim 1, and

(B) effecting the electrodeposition of the alloy on the substrate through the use of said bath.

19. The process of claim 18 wherein the substrate is a cylinder of an internal combustion engine.

20. A process for electrodepositing an iron-phosphorus alloy on a conductive substrate which comprises

5 (A) providing an acidic aqueous electroplating bath of claim 10, and  
(B) effecting the electrodeposition of the alloy on the substrate through the use of said bath.

21. A conductive substrate having an iron-phosphorus alloy deposited thereon, said deposited alloy being formed by electrodeposition from the bath of claim 1.

10 22. The conductive substrate of claim 21 wherein the alloy comprises from about 1 to about 30 atomic percent of phosphorus.

23. The conductive substrate of claim 21 wherein the alloy comprises from about 70 to about 99 atomic percent of iron.

15 24. The conductive substrate of claim 21 wherein the alloy comprise from about 0.1 to about 0.5 atomic percent of sulfur.